THE EFFECT OF ANCYLOSTOME, ASCARIS, AND TRICHURIS INFECTIONS ON THE HEALTH OF THE WEST AFRICAN NATIVE

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PLATE VII

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I. INTRODUCTION

The limitations of the work must first of all be made clear.

1. It deals solely with the West African male native, as studied at Freetown, and any conclusions drawn apply only to this race.

2. It is concerned only with the effects of the infection on the individual; it is not concerned with the importance of the infected individual as a propagator of the disease.

3. The lesions and symptoms produced by migrating larvae are considered to be a separate subject and are not discussed.

4. The effect of treatment is not considered; whereas this subject is obviously one of great importance, it appears to the writer that the first and most important consideration is the effect, if any, of ancylostome infection on different races of mankind.

5. No distinction is drawn between infection with *A. duodenale* and *N. americanus.* Darling and others (1920) and Darling (1922) show that *A. duodenale* is more important as a producer of anaemia than an equal infection with *N. americanus.* Adler (1925) gives the proportion of *A. duodenale* to *N. americanus* in Freetown as 1 : 10.

Malaria and ankylostomiasis are usually accepted as the most important diseases affecting natives in West Africa, and certainly entail a greater expenditure of money than any other two diseases. The effects of Malaria are definite, and the pathological changes which it produces in the individual can be demonstrated and classified, while the value of its eradication is too obvious to need argument. The position as regards ankylostomiasis appears to be entirely different ; the causal organism and its life cycle are established, and the value of its eradication appears generally accepted, but the effect of the worm on its host and the pathological lesions produced by it seem to be subjects evoking the widest differences of opinion, ranging from those who regard ankylostomiasis in general as having little effect on the human host, to the other extreme, which considers that any infection, however light, is responsible for illness of the individual, and calls for immediate treatment ; between these two extremes are to be found numerous observers who consider that a certain concentration of worms must be present in the gut before any symptoms appear. Unless it is conceded therefore, that any infection, however small, is pathogenic, it is obvious that any attempt to define the pathogenicity of ankylostomiasis must include a statement showing the degree of infection of the individuals considered ; it is doubtful if any value can be attached to mere comparisons of infected and uninfected individuals, such comparisons being frequently made and often illustrated with photographs showing poorly developed individuals suffering from ancylostome infection as diagnosed by the finding of ova (the number not being stated) in the stool, and well-developed, athletic-looking individuals free from infection. The two photographs accompanying the present article represent, in the one case, six boys selected at random from amongst the heaviest infections, and in the other case, six boys selected at random from amongst the negative or lightly infected group ; if anything, it is the heavily infected group which appears to show the best physique. In the enormous bibliography of hook-worm disease definite figures of the degree of infection of the cases considered are surprisingly few, this lack of figures being, of course, largely due to the fact that until the publication of Stoll's (1923) method of estimating the number of ova in a given sample of faeces, there was little uniformity of opinion as to what constituted a ' light ' or ' heavy ' infection, and it is probably this lack of uniformity of opinion that has led to the surprising diversity of statements concerning the pathogenicity of ankylostomiasis.

Another difficulty encountered is that the literature dealing with ankylostomiasis appears almost entirely to ignore concomitant infections with other gut helminths, even when the pathogenicity of such helminths is admitted by the authors of the publication.

During the first part of the present work, which consisted in examining prison cases, the writer was impressed with the high proportion of Ancylostome cases which were also infected with Ascaris or Trichuris or both ; in subsequent examinations, therefore, a count was kept of these ova, and a classification made of the cases on the same lines as in the ancylostome work. Infection with the larvae of *Strongyloides stercoralis* was also common in Freetown, as noted by Maplestone (1924) ; they are not recorded here owing to the difficulty of estimating the degree of infection, which varied enormously with the consistency of the stool. Ova of a cestode (probably *T. saginata*) and on one occasion those of *S. mansoni* were also noted ; both infections were rare and when seen the ova were too few in number to be worth estimating.

Granted that ankylostomiasis is pathogenic, there still remain great differences of opinion as to the manner in which this pathogenicity manifests itself in the individual and what lesions, if any, the worm produces in the gut. Thus a perusal of the ' Rockefeller Bibliography of Hookworm Disease ' (1922) shows that it tabulates articles on almost every conceivable sign and symptom ranging from arthritis to night-blindness. The present writer attempted to compile a table summarising the views of modern authorities on the subject, but it was found that such a table became hopelessly unwieldy, as it had to include columns for almost every system and organ of the body. Most, though not all, authorities are, however, agreed *that ancylostome infection adversely affects the host by producing* (1) *Anaemia,* (2) *Poor physique,* (3) *Mental dullness,* (4) *Lack of* *energy*. It is with these four points that the present paper, which deals with 137 natives, of whom 114 (83 per cent.) were infected, is concerned.

The number of cases dealt with is small and it may at first seem unnecessary to add them to the already overburdened literature on the pathogenicity of ankylostomiasis, but the information concerning these cases has been made as comprehensive and as exact as possible, whereas, as already stated, by far the greater proportion of published literature on this subject lacks figures showing the degree of infection of the cases under consideration and abounds in statements associating this or that symptom with ancylostome infection, such statements being unsupported by any proof except the finding of an unestimated number of ancylostome ova in the stool of the patient. It is interesting in this connection to consider the following statements. Stephens (1916), quoting Löbker and Bruns (1906), writes ' Whilst up to modern times it has been generally maintained that the great majority of worm diseases cause more or less marked symptoms, the exact investigations of the last few years have made it plain that the great majority of people with worms are not only perfectly healthy, but the most careful clinical observations show no single sign of any ill-effect of the intestinal parasites on the health of the host (Löbker and Bruns).' Clayton Lane (1917) points out that the reference date of Löbker and Bruns is 1906 and dismisses the whole statement as being out of date ; referring to the Rockefeller Sanitary Commission for the Eradication of Hookworm Disease and the Rockefeller International Health Commission, Lane continues as follows : ' It is obvious that the opinions based on this enormous experience, which in the five years of the Sanitary Commission's existence, covered over 1,300,000 persons, carries a weight borne by those of no other person or scientific body in the world ; and that should any individual elect to differ, the onus of fully justifying his own attitude must lie with himself.' Such a statement as this has the natural effect of deterring the individual observer from adding his small quota to so vast an array of figures ; no one who has studied the literature of the Rockefeller Commission can but be impressed with the magnificent work published and the splendid results obtained by this body of investigators. Yet at the time of Lane's paper (1917) the present writer is unaware of any paper published by the Rockefeller Commission which dealt with the degree of infection of the persons considered, except in a few instances where a rough comparison is made by the general appearance of the number of ova in the stool ; the whole of the 1,300,000 cases referred to are only considered as a comparison of infected and uninfected individuals ; thus Strong (1916) investigated the effects of ankylostomiasis on the physique and mentality of 115 school children and drew the following conclusions.

' (1) *Our figures show that hookworm disease interferes with physical development. Treatment alleviates this condition to a considerable extent. Apparently young children can regain most of the physical conditions, if not all, which they have lost due to the infection.* But the data do also very strongly suggest that the severer the infection and the longer it persists, the less likely it is that the child will ever reach his normal physical development.' He draws the following conclusions as a result of the mental tests. ' The figures show, then, that hookworm disease unmistakably affects mental development. *Treatment alleviates this condition to some extent but it does not, immediately, at least, permit the child to gain as he would if he had not had the disease. And the figures apparently further show that prolonged infection may produce prolonged effects upon mentality—effects from which the individual may never entirely recover.*' No estimation was made in these cases of the concentration of ova in the stools or the number of worms in the intestines of the children. The consideration of these cases, therefore, resolves itself essentially into a comparison of infected and uninfected cases.

Our present knowledge shows that such a comparison is liable to very wide error. To quote one instance only : Hill (1923) records 282 cases, of whom 142 with 1 to 2,099 ova per gm. showed no symptoms, while 57 with 2,100 to 5,099 only showed very slight and indefinite symptoms. A few months prior to the publication of this paper, Lane (1923b) wrote as follows : ' It is at least certain that there is a growing mass of evidence that the so-called carrier is improved in health and working power by disinfestation, and I know of no published evidence suggesting that there is any limit below which infestation is immaterial. Statements of personal belief on this matter appear misplaced. The fact seems to be that there is no satisfactory evidence, either for or against the belief that the lightest infestations are immaterial to their host.' This statement would appear to the present writer to be a very fair summary of the state of affairs at the time the paper was published, except that the latter portion of the statement seems to negative the value of the remarks as regards the so-called carrier being improved in health and working power by disinfestation, and would also appear to indicate that Lane has considerably modified his previous views, as in 1919 he states : 'Each year adds to the accumulated facts indicating that even light infections are a definite handicap to growth in wisdom and stature, and to the full possession of that modicum of health and wealth which makes life worth living.'

A search of the literature has shown that the following are the more important papers dealing with the effects of ankylostomiasis on the host when the degree of infection is approximately known. (1) Darling, Barber and Hacker (1920) ; (2) Darling and Smillie (1921) ; (3) Smillie (1922) ; (4) Hill (1923) ; (5) Cort, Payne and Riley (1923) ; (6) Mhaskar and Kendrick (1923) ; (7) Cort (1924) ; (8) Mhaskar (1924) ; (9) Chandler (1925) ; (10) Stoll and Tseng (1925). The work of these writers on the pathogenicity of ankylostomiasis is almost entirely concerned with the question of anaemia, and there appears to be a great need of further investigation as to its effects on the health and mentality of different native races.

It will be noted that the above summary refers only to ankylostomiasis ; the writer is unaware of any publication dealing with the pathology of Ascaris or Trichuris infection based on a knowledge of the intensity of the infection in the individuals concerned.

II. CASES AVAILABLE, CLASSIFICATION OF CASES, COLLECTION OF MATERIAL

Only cases which were under constant supervision and discipline were selected. They were chosen from amongst three sections of the native male community in Freetown. (1) 49 youths aged 10 to 22 (average age 18) attending school, the majority as boarders ; (2) 40 City Police of all ages from 23 to 50 ; (3) 48 gaol prisoners of all ages from 17 to 49. One hundred and thirty-seven cases were thus examined, the work occupying about four hours daily for a period of eight months.

In every case the examination, as regards physique, mentality and energy, was carried out by the officer in charge of the institution concerned, according to a fixed scheme previously carefully discussed and agreed upon between the officer and the Laboratory. In order to avoid any bias that might result from any previous knowledge, the officers in charge of the institutions did not know the degree of infection of the inmates, and the Laboratory was unaware of the classification of the cases it was examining. The haemoglobin percentage, as shown by a Talquist scale, was estimated by the writer who was not aware of the identity of the particular case he was at the time investigating. In addition to the haemoglobin estimation, each case was examined as regards three other categories : (1) Physique and general fitness, (2) Mentality, and (3) Energy, and placed in order of merit, in an *A*, *B* or *C* class in each of these three categories.

The physical examination requires no special comment ; it was not necessarily a medical examination (though the doctor's report was usually available) but consisted in placing the native in class *A*, *B*, or *C* according to his general physique and fitness when seen stripped.

The mental examination was not directed to ascertain how much the individual knew, but rather to discover his mental alertness and ability to learn ; thus a boy at the head of his class might be placed in category *C* because he had gained his position at the head of the class by remaining behind when brighter boys had been moved on. The mental classification was comparatively simple in the case of the boys and police who were being regularly taught and questioned, but in the case of the gaol prisoners, it had to consist of an examination of the man's mental ability as judged by the answers he gave to a series of simple questions.

Energy was defined as the keenness with which an individual attempted any mental or physical task allotted to him ; it was frequently found that this classification gave very different results from the other two ; thus a native might be classed as physically poor (*C*) and mentally dull (*C*), but as regards energy very good (*A*) because, though his ability to perform any task, whether physical or mental, allotted to him, was bad, yet the energy he showed in trying to perform the task was excellent.

Strong (1916) has published a long and very carefully detailed account of his investigations on the effects of ankylostomiasis on the physique and mentality of 115 school children living in a ' hookworm infected county.' He divided the children into five groups according to whether ' (1) They were not infected (Group A) ; (2) They were infected but not treated (Group B) ; (3) They were infected and later cured (Group C) ; (4) They were infected and treated but not completely cured (Group D) ; or (5) They were infected and treated but the final condition of their infection could not be determined (Group E).'

The tests applied to these groups were extremely ingenious and interesting, but appeared too complex for use in a native community such as Freetown. The question of Strong's conclusions from these tests has already been dealt with (see Introduction).

The classification having been completed, the case was issued with a faeces container marked with his number and, as a rule, the specimen was passed under the observation of an individual appointed for the purpose ; the specimen was then dispatched to the Laboratory and examined according to the technique described later. The information regarding the case was therefore tabulated on two forms, one form being filled in by the Laboratory and the other by the person in charge of the school, barracks, or gaol, the two portions being compared together only when the work was completed. In the case of the 48 gaol prisoners only ancylostome ova were counted and facilities for haemoglobin estimation were not available ; in the case of the 40 city police and the 49 youths attending school, Ascaris and Trichuris ova were counted in every case, and in 84 of the 89 cases the haemoglobin percentage was also estimated.

III. TECHNIQUE OF ESTIMATING THE NUMBER OF OVA IN THE FAECES

Stoll (1923) published a technique for counting hookworm eggs in faeces, and in 1924, he published a further paper in the conclusions of which he states ' A relationship of approximately 1 : 2 : 4 is found to exist in general between the weighed amounts of formed, mushy (unformed), and diarrhoea faeces, passed per day. This affords an easy interpolation by which to bring counts made on faeces of any of the three categories to a similar plane, the basis of formed faeces, so that they can be compared *inter se*.' The reader is referred to these two papers for details of the technique, which was exactly adhered to except for the following trifling modifications and additions. (*a*) Stoll balances the container and its faeces on the scales and removes 3 gm. into a large test-tube containing three glass beads and 45 c.c. of $\frac{N}{10}$ NaOH. The writer found it simpler and less messy to stir thoroughly the specimen of faeces and weigh out 3 gm. into a small metal container previously balanced on the scales, and then slide the metal dish, containing the 3 gm. of faeces, into the large test-tube and add 45 c.c. of $\frac{N}{10}$ NaOH and three glass beads. The metal dish aids greatly in rapid emulsification of the faeces when shaking the tube, and is also very convenient for dealing with liquid faeces. The dish referred to is made of the thin tin used in sealing boxes of cigarettes sent to the tropics ; the tin should be cut into a square and the four corners inbent so as to form a rectangular water-tight trough measuring about 2 in. $\times$ $\frac{3}{4}$ in. $\times$ $\frac{1}{2}$ in. (*b*) Stoll says the diluted faeces ' was immediately sampled with a pipette graduated at 0.15 c.c.' It will be found in practice that in some cases faecal debris adheres to the outside of the pipette and interferes with accuracy by draining into the fluid which is being discharged on to the counting glass ; in order to avoid this error it is advisable to draw up fluid past the 0.15 c.c. mark, rapidly wipe the outside of the pipette with a wisp of wool, discard the excess of fluid and discharge the remaining 0.15 c.c. on to the counting glass. It is necessary to perform this operation very rapidly in order to avoid sedimentation occurring. (*c*) Stoll measures 0.15 c.c. of the diluted faeces on to a large slide and covers this with a single 22 $\times$ 40 mm. coverslip. The writer found it more convenient to use three amounts of 0.05 c.c. and count each separately. (*d*) A small point, but one which, if neglected, interferes with accuracy, is that the surplus uncovered fluid lying along the edge of the coverslip should be first examined, otherwise the rapid drying up which occurs in the tropics will render the counting of ova difficult. (*e*) At the commencement of the work it was found that certain bodies, probably derived from some vegetable in the native dietary, imitated unfertilised Ascaris ova with such extreme fidelity, both as regards size and morphology, that they necessitated careful examination with the high power in order to differentiate them from ova ; it was therefore decided to include only ' fertile ' Ascaris, Ancylostome or Trichuris ova in the counts. (*f*) Chandler (1925) advocates examining uncovered preparations, as by this method one can blow aside obscuring flocculi of undissolved faecal debris, while doubtful egg-like objects can be verified by blowing on the fluid and causing them to roll about. The writer tried this method prior to the publication of Chandler's paper and abandoned it because it was found that any current of air occurring in the laboratory caused the ova in the fluid to move about and lose their position in the field which was being counted.

IV. ACCURACY OF STOLL'S METHOD AND ITS VALUE IN COMPARING THE DEGREE OF INFECTION IN DIFFERENT INDIVIDUALS

Stoll (1923), when describing his method of estimating the number of hookworm eggs in faeces, claimed that this technique was ' accurate to within 10 per cent.', while Maplestone (1924), who tested the accuracy of the method by control counts of ova made with saturated salt solution, and cultures of larvae made from the same faeces sample, came to the conclusion that the method was ' not accurate to within 10 per cent.'

In order to compare together the ovum content of stools of different consistencies, Stoll (1924) advocates the taking of a formed stool as a standard and multiplying the ovum content of a mushy stool by two and a liquid stool by four (this being the method adopted in the present work) ; Chandler (1925) regards mushy stools as normal for the Indian native, and therefore divides the results obtained from formed stools by two and multiplies those of liquid stools by two ; whatever the accuracy, therefore, of any technique for estimating the number of ova in a single given sample of faeces, it is obviously absurd to discuss the finer points of accuracy of such a technique when applied to the estimation of the average number of ova in a series of stools varying in consistency, for the definitions ' formed ' ' mushy ' (or ' semi-solid ') and ' liquid ' are not fixed definitions, and an examination of even as few as fifty specimens will convince any worker on this subject that every variation between these standards is to be found, where one observer will define a stool as mushy and multiply his result by two, another will call it liquid and multiply his result by four. A clear-cut distinction must, therefore, be drawn between estimating the number of ova in a given sample of faeces, and the comparing together of the average number of ova passed by different individuals on different occasions ; it is obvious that the first can be performed to any degree of accuracy if sufficient time and care are expended ; thus Stoll's method admittedly does not detect the presence of ova in the stool if less than 100 per gm. be present. Therefore all single worm infections will be missed. Now Lane's (1923-1925) method will detect less than this concentration and clearly, therefore, his method is more accurate and, therefore, more suitable for such an estimation. The present work, however, is not concerned with such an estimation, but is concerned with the comparison of the ovum content of the stools of different individuals on different occasions ; now the ovum content of such stools may vary according to the quantity of faeces passed (presumably the less food taken the smaller the quantity of faeces and the greater the concentration of the ova), the consistency of the faeces, and the fecundity of the worms. When such a number of uncontrolled factors exist the more minute points of accuracy are of little importance ; what is required is a method whereby negative (by negative is meant less than 100 ova per gm.), moderate, and heavy infections can be compared together, and for this purpose Stoll's technique seems well adapted. That such comparative accuracy is obtainable by Stoll's method appears to be proved by the figures given in Table I. It is of interest to note that the counts of Ascaris and Trichuris infections do not correspond nearly as closely as do those of anclystome infections, a possible explanation being that fewer worms are present in the two former infections and that the variations in the fecundity of the worms are, therefore, more clearly noticeable.

For further particulars regarding the comparative accuracy of Stoll's (1923) and Clayton Lane's (1923-1925) method, the reader is referred to articles by Sweet (1924) and Chandler (1925b).

Tables Ia, Ib, Ic.

Showing the number of ova actually counted in 0·01 gm. of faeces in the same individual on three occasions, amongst a series of 114 positive Ancylostome cases, 16 positive Ascaris cases, and 39 positive Trichuris cases. Solid specimens are shown by black figures. When a specimen was 'mushy' or 'semi-solid' the result has been × 2, and when liquid × 4. For the purpose of reference the numbers given to the cases have been adhered to throughout the tables and text.

Table Ia.—One hundred and fourteen Positive Ancylostome Cases.

Note.—The occurrence of a decimal point in a few of the cases is due to the figure being the average of a series of counts on the same specimen.

Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1st examination...	32	0	3	24	50	38	2	6	0	3	0	13	4	26	13	3	2	3	9	7	10	8	9	17	54	2	11	3	5
2nd examination	32	2	1	44	67	38	1	3	1	4	4	11	1	12	8	2	0	1	8	8	7	6	29	23	50	4	9	8	4
3rd examination	28	0	2	49	49	30	1	4	1	3	2	9	6	28	35	0	6	2	9	6	12	6	4	18	53	5	9	17	5

Case	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
1st examination...	4	6	26	203	41	128	0	122	154	21	16	12	15	304	272	50	10	196	53	38	102	75	30	97	122	92	15	65	27
2nd examination	2	9	19	122	48	140	0	110	127	27	17	18	22	313	295	42	4	62	48	42	70	111	43	81	122	114	13	76	53
3rd examination	0	5	18	143	43	144	4	61	117	37	22	17	20	488	126	26	13	135	50	77	109	130	40	70	136	130	11	70	31

Case	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87
1st examination...	1	175	16	40	2	5	21	3	5	8	0	5	271	1	43	4	29	128	66	13	2	23	0.5	5	4.5	46	9.5	4.5	53
2nd examination	4	155	17	25	3	2	11	3	7	13	0	2	188	7	42	2	37	178	56	15	8	7	0	6	4	51	32	6	39
3rd examination	10	79	13	29	0	3	19	0	4	12	1	3	174	5	57	4	34	96	55	12	3	22	3	16	5	88	32	5	50

Case	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
1st examination...	23	70	5	0	22	0	2	10	0.5	0	4	23	92	1	27	6	79	14	19	2	3	4	30	1	34	1412	141
2nd examination	20	80	15	0	16	0	2	4	1	2	13	43	165	2	76	8	77	13	33	1	12	7	39	2	20	1070	210
3rd examination	29	31	12	16	54	16	1	4	0	0	32	25	128	1	...	0	65	19	...	2	5	8	...	4	18	...	182

Table Ib.—Sixteen Positive Ascaris Cases.

Case	3	115	116	30	38	43	51	57	117	64	65	66	72	74	119	75
1st examination	44	115	48	164	507	96	31	102	61	5	34	192	63	218	21	16
2nd examination	12	103	53	214	317	103	42	48	88	2	37	126	134	92	31	16
3rd examination	30	88	27	144	455	291	44	124	134	4	54	214	64	275	30	47

Table Ic.—Thirty-nine Positive Trichuris Cases.

Case	1	120	6	7	8	11	12	14	15	17	19	20	21	22	23	24	121	26	122	31
1st examination	0	1	2	1	1	0	0	8	10	1	1	0	3	4	0	0	0	6	2	5
2nd examination	0	0	2	0	1	2	3	1	4	1	0	19	1	2	1	2	2	0	0	0
3rd examination	2	0	2	2	0	0	1	2	16	0	1	48	4	3	0	0	1	1	2	3

Case	35	38	43	49	123	60	117	62	63	64	68	124	125	69	73	74	119	75	76
1st examination	0	0	52	1	3	1	3	0	0	3	0	1	3	1	5	14	5	0	2
2nd examination	2	1	48	4	2	6	0	0	0	0	0	3	2	0	6	12	4	0	2
3rd examination	0	0	134	5	...	7	0	2	1	1	1	4	0	2	17	10	3	3	2

V. EFFECTS OF ANCYLOSTOME, ASCARIS, AND TRICHURIS INFECTIONS ON THE (*A*) HAEMOGLOBIN PERCENTAGE, (*B*) PHYSIQUE AND GENERAL FITNESS, (*C*) MENTALITY, (*D*) ENERGY, AND (*E*) URINE, OF WEST AFRICAN NATIVES

In the results which follow, the degree of infection is expressed as the average number of ova per gm. of faeces, this figure being the mean of three Stoll counts on each individual case, except that five cases amongst the 137 examined for ancylostome infection, and two each amongst the eighty-nine Ascaris and eighty-nine Trichuris series were only examined on two occasions, the natives concerned having left the Institution before the third examination was completed. The counts were usually made at intervals of four to seven days, but occasionally longer periods intervened. The expression 'average number of ova per gm. of faeces,' when applied to a number of cases constituting a group or class, includes negative cases, that is to say, it is the figure arrived at by adding together the average number of ova per gm. of faeces of each member of the group and dividing the result by the total number of individuals in that group; the same rule holds good for the heading 'average number of ancylostomes per individual.' The figures for the number of ancylostomes are, of course, only roughly approximate, but they are included in the tables as they would appear to give a more concrete idea of the degree of infection; the estimation of the number of ancylostomes is based on the supposition that every forty ova per gm. of faeces represents one adult female worm; this relation between ova per gm. and parent worm is given by Stoll (1923b) as 44 to 1, by Darling (1922) as 22 to 1, by Lane (1923) as 33 to 1, and by Davis (1924) as 85 to 1. To this figure must be added the proportion of male worms which is here estimated as two males for every three females (see Darling, Barber and Hacker (1920), Stoll (1923b), Adler (1925)). The final formula is, therefore, $\frac{x}{40} + \frac{2}{3}\left(\frac{x}{40}\right)$ where x is the number of ova per gm. of faeces. Figures of the number of Ascaris and Trichuris present in the gut are omitted, as there appears to be no authoritative statement as regards the average daily egg production of these two species, except those of Davis (1924) who, as the result of the examination, and subsequent treatment, of sixteen positive Ascaris cases computes the average number of eggs per female, per gm. of faeces, to be 3,466, and Moosbruger, as quoted by Brumpt (1922), who, as the result of an autopsy, gives the Trichuris figure as seven ova per female per gm. of faeces.

The influence of Ancylostome, Ascaris and Trichuris infections will be considered as regards their effects on five conditions. (A) Haemoglobin percentage. (B) General physique and fitness. (C) Mentality. (D) Energy. (E) Urine.

(A) *Haemoglobin percentage.* It will be seen that Table II lends no support to the commonly accepted view that Ancylostome infection tends to lower the haemoglobin reading ; nor do Ascaris or Trichuris infections appear to have any influence, for it can be seen that the group with the higher haemoglobin reading actually contains a slightly higher average degree of infection than the group with the lower haemoglobin reading. It is perhaps unfortunate that the haemoglobin readings in the two groups approximate so closely, but this was unavoidable as the haemoglobin readings in all the West Africans examined fell between 90 and 70 per cent.

Table II.

Showing the percentage of individuals infected with Ancylostome, Ascaris, and Trichuris, and the average degree of infection, in each of two groups of West African natives classified according to the haemoglobin reading.

Groups based on Haemoglobin per cent.	Number of cases examined	Percentage infected with			Average number of ova per gm. of faeces			Maximum number of ova per gm. of faeces			Computed average number of Ancylostomes per individual
		Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	
A 81–90 % Hb	57	86	19	47	3,670	1,878	125	21,100	42,630	2,230	150
B 71–80 % Hb	25	84	16	36	2,890	1,947	118	23,100	19,500	933	120

The question now arises whether intense infection produces any marked change ; with the object of investigating this point the ten heaviest infections in the case of each worm are set forth in Table III.

Table III.

Showing the ten heaviest Ancylostome, Ascaris, and Trichuris infections observed amongst West African natives, and the haemoglobin reading for each case.

Ancylostome				Ascaris			Trichuris		
Case	Haemoglobin per cent	Number of ova per gm. of faeces	Computed number of Ancylostomes	Case	Haemoglobin per cent.	Number of ova per gm. of faeces	Case	Haemoglobin per cent.	Number of ova per gm. of faeces
44	70	23,100	962	38	80	42,630	20	80	2,230
71	80	21,100	879	74	75	19,500	15	80	1,000
33	80	15,600	650	66	75	17,733	73	75	933
35	85	13,700	570	30	85	17,400	74	75	900
60	90	13,600	567	115	80	10,300	60	90	460
76	85	13,400	558	117	80	9,430	119	75	400
38	80	13,200	550	57	85	9,130	14	80	360
47	70	13,100	546	72	75	8,700	49	90	330
54	90	12,660	527	116	80	4,260	22	85	300
55	70	11,200	466	65	85	4,160	124	85	266

It will be seen from Table III that, broadly speaking, two-thirds of the heaviest infections in the case of each worm fall into the higher haemoglobin group ; moreover, if we consider the haemoglobin content of those natives who were uninfected, we find that of the eighty-two cases in which haemoglobin readings were made, twelve were negative as regards ancylostomes, and of these eight fell into the higher haemoglobin group and four into the lower. Sixty-seven were negative as regards Ascaris, and of these forty-six fell into the higher haemoglobin group and twenty-one into the lower. Forty-six were negative as regards Trichuris, and of these thirty fell into the higher haemoglobin group and sixteen into the lower. Thus it appears that roughly two-thirds of the heaviest infections and two-thirds of the negative cases fell into the higher haemoglobin group, and this figure corresponds with the relative size of high and low haemoglobin groups amongst the total eighty-two natives examined, that is, 57 to 25.

From these facts it seems clear that there is no correlation between intensity of infection in the individual and the haemoglobin reading. It might, of course, be argued that all the natives under consideration exhibited some degree of anaemia ; this may be so but it must be borne in mind that in none of the eighty-two West African natives—whether infected or uninfected—chosen at random, was the haemoglobin reading more than ninety, so that in any case, if the readings in this series were less than normal, this anaemia cannot be due to any of the three worms under consideration.

Conclusions regarding the influence of Ancylostome, Ascaris, and Trichuris infections on the haemoglobin percentage of eighty-four West African Natives.

1. A group of individuals with a low haemoglobin percentage does not show a greater percentage of infected cases than a group with a higher haemoglobin percentage.

2. A group of individuals with a low haemoglobin percentage does not show a greater average degree of infection than a group with a higher haemoglobin percentage.

3. Individuals with a high degree of infection do not necessarily show a low haemoglobin percentage.

This tolerance, so far as ankylostomiasis is concerned, would appear to be shared by some, at any rate, of the Indian races. Thus Mhaskar and Kendrick (1923), working in the tea estates of Madras, report as follows :—' There is no correlation between the haemoglobin average and the number of hookworms harboured ; the presence of anaemia is not necessarily a sign of heavy infection.' Chandler (1925), using Stoll's technique, writes : ' In a study of 100 individuals in the Alipore Central Jail, Calcutta, sixty-seven of whom were infected with hookworm, but only six of whom had more than 1,000 eggs per gm. of faeces, no differences in haemoglobin percentage between the infected and uninfected individuals could be found.'

On the other hand, Stoll and Tseng (1925), working with Chinese cases, trace a definite connection between the number of ancylostomes harboured and the degree of anaemia ; it is important to note, however, that the haemoglobin percentage of sixty-four ancylostome-free cases only averaged 66.7 per cent. and concerning these they write : ' The malaria is held to account for the low average haemoglobin of the hookworm negatives, and probably also influenced the degree of anaemia in the hookworm positives.'

(B) *Physique and General Fitness.* From a consideration of the figures in Table IV it is clear that the percentage of positive ancylostome cases is approximately equal in all three groups; on the other hand, there appears at first sight to be a very definite relationship between the average degree of infection and the physical standard of the group in which the cases occur; on consulting the column of maximum infections, however, it will be seen that the maximum infections occurring in Group B and Group C are much higher than that in Group A.

TABLE IV.

Showing the percentage of individuals infected with Ancylostome, Ascaris, and Trichuris, and the average degree of infection, in each of three groups of West African natives classified according to their physique and general fitness.

Groups based on physique and general fitness	Number of cases examined	Percentage infected with			Average number of ova per gm. of faeces			Maximum number of ova per gm. of faeces			Computed average number of Ancylostomes per individual
		Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	
A (Good)	For Ancylostomes only—32 For Ancylostomes, Ascaris and Trichuris—50	84	22	44	2,619	2,418	102	15,600	42,630	933	109
B (Moderate)	For Ancylostomes only—5 For Ancylostomes, Ascaris and Trichuris—31	83	16	39	4,381	1,651	335	36,830	17,733	7,800	183
C (Bad)	For Ancylostomes only—11 For Ancylostomes, Ascaris and Trichuris—8	84	0	62	9,420	0	340	124,000	0	2,200	392

It is obvious that when one is dealing with a comparatively small number of cases a single pre-eminently heavy infection may be sufficient to raise to a considerable extent the average degree of infection of the whole group; and on enquiring into the question it was found that the maximum infections in Group B and Group C, shown in Table IV, were in fact outstanding, as the next highest infection in Group B was 23,100, and in Group C 17,760. Turning to a consideration of the Ascaris and Trichuris infections it was similarly discovered that in each case there was a pre-eminently high infection, viz., 42,630 Ascaris ova per gm. in Group A, and 7,800 Trichuris ova in Group B. A truer picture is, therefore, obtained by omitting these predominantly high infections, and this is done in Table IVA.

TABLE IVA.

Table IV modified by the omission of the four predominantly high infections.

Groups based on physique and general fitness	Number of cases examined	Percentage infected with			Average number of ova per gm. of faeces			Maximum number of ova per gm. of faeces			Computed average number of Ancylostomes per individual
		Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	
A (Good)	For Ancylostomes only—32 For Ancylostomes, Ascaris and Trichuris—49	84	20	44	2,619	1,597	102	15,600	19,500	933	109
B (Moderate)	For Ancylostomes only—5 For Ancylostomes, Ascaris and Trichuris—30	83	16	37	3,453	1,651	86	23,100	17,733	1,000	144
C (Bad)	For Ancylostomes only—10 For Ancylostomes, Ascaris and Trichuris—8	83	0	62	3,054	0	340	17,760	0	2,200	128

It is seen from Table IVA that no definite correlation exists between the physical standard of a group and the percentage of infected cases, or the degree of infection occurring in that group.

Turning to the subject of the effect of intense infections, Table IV shows that the total number of cases examined for ancylostomes was 137; of these eighty-two (60 per cent.) fell into Group A, thirty-six (26 per cent.) fell into Group B, and nineteen (14 per cent.) into Group C. Eighty-nine natives were examined for Ascaris and Trichuris infections and were found to be distributed amongst the three groups in the following proportions; Group A, fifty (56 per cent.), Group B, thirty-one (35 per cent.), and Group C, eight (9 per cent.). It is now necessary to consider the distribution of the ten heaviest infections with each species of worm amongst the three groups, and to compare this distribution with that of the uninfected cases.

TABLE V.

Showing the ten heaviest Ancylostome, Ascaris, and Trichuris infections observed amongst West African natives, and the standard of physique and general fitness for each case.

Ancylostome				Ascaris			Trichuris		
Case	Standard of physique	Number of ova per gm. of faeces	Computed number of Ancylostomes	Case	Standard of physique	Number of ova per gm. of faeces	Case	Standard of physique	Number of ova per gm. of faeces
113	C	124,000	5,167	38	A	42,630	43	B	7,800
43	B	36,830	1,537	74	A	19,500	20	C	2,200
44	B	23,100	962	66	B	17,733	15	B	1,000
71	B	21,100	879	30	A	17,400	73	A	933
114	C	17,760	740	43	B	16,630	74	A	900
33	A	15,600	650	115	B	10,300	60	A	460
35	B	13,700	570	117	A	9,430	119	A	400
60	A	13,600	567	57	A	9,130	14	A	360
76	A	13,400	558	72	B	8,700	49	B	330
38	A	13,200	550	65	B	4,260	22	A	300

From Table V it can be seen that the ten heaviest infections with Ancylostome, Ascaris, or Trichuris, are in each case distributed according to the size of the group. Amongst the ten most intense Ancylostome infections 40 per cent. occur in Group A, 40 per cent. in Group B, and 20 per cent. in Group C ; an examination of twenty-three natives who were not infected with Ancylostomes showed that 61 per cent. fell into Group A, 26 per cent. into Group B, and 13 per cent. into Group C. Of the ten heaviest Ascaris infections 50 per cent. occurred in Group A, and 50 per cent. in Group B ; and of the seventy-three cases negative for Ascaris, 53 per cent. fell in Group A, 36 per cent. in Group B, and 11 per cent. in Group C. Amongst the ten heaviest Trichuris infections 60 per cent. occur in Group A, 30 per cent. in Group B, and 10 per cent. in Group C ; fifty cases free from Trichuris infection occurred in the different groups in the following percentages, Group A, 56 per cent., Group B, 38 per cent., and Group C, 16 per cent. These figures, therefore, show no noticeable association between an intense infection with Ancylostome, Ascaris, or Trichuris, and a lowered standard of physique and general fitness.

Conclusions regarding the influence of Ancylostome infection on the physique and general fitness of 137 West African natives, and that of Ascaris, and Trichuris infections on eighty-nine of the same cases.

1. A group of individuals with a lower standard of physique and general fitness does not necessarily show a noticeably greater percentage of infected cases than a group with a higher standard of physique and general fitness.

2. A group with a lower standard of physique and general fitness does not necessarily show a noticeably greater average degree of infection than a group with a higher standard of physique and general fitness.

3. Individuals with a high degree of infection do not necessarily show a low standard of physique and general fitness.

(C) *Mentality.* It has already been stated in the Introduction that the mental examination was not directed to ascertaining how much the individual knew, but rather to discovering his mental alertness and ability to learn. In Table V are set out the percentage of infected cases, and the degree of infection, occurring amongst West African natives classified on this basis.

Table VI.

Showing the percentage of individuals infected with Ancylostome, Ascaris, and Trichuris, and the average degree of infection, amongst West African natives arranged in three groups according to their mentality.

Groups based on mentality	Number of cases examined	Percentage infected with			Average number of ova per gm. of faeces			Maximum number of ova per gm. of faeces			Computed average number of Ancylostomes per individual
		Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	
A (Good)	For Ancylostomes only—8 For Ancylostomes, Ascaris and Trichuris—17	76	12	47	1,218	1,578	65	8,260	17,400	300	51
B (Moderate)	For Ancylostomes only—10 For Ancylostomes, Ascaris and Trichuris—43	85	19	42	4,050	2,350	132	23,100	42,630	1,000	169
C (Bad)	For Ancylostomes only—30 For Ancylostomes, Ascaris and Trichuris—29	85	21	45	5,193	1,523	392	124,000	17,733	7,800	216

The four predominant infections shown to be present in Table IV are, of course, also present in Table VI ; the two Ancylostome infections and the one Trichuris infection occurring in Group C, and the predominant Ascaris infection in Group B. Omitting these four cases we have the results shown in Table VIA.

TABLE VIA.

Same as Table VI except that four predominantly high infections have been omitted.

Groups based on mentality	Number of cases examined	Percentage infected with			Average number of ova per gm. of faeces			Maximum number of ova per gm. of faeces			Computed average number of Ancylostomes per individual
		Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	
A (Good)	For Ancylostomes only—8 For Ancylostomes, Ascaris and Trichuris—17	76	12	47	1,218	1,578	65	8,260	17,400	300	51
B (Moderate)	For Ancylostomes only—10 For Ancylostomes, Ascaris and Trichuris—42	85	17	42	4,050	1,391	132	23,100	19,500	1,000	169
C (Bad)	For Ancylostomes only—29 For Ancylostomes, Ascaris and Trichuris—28	84	21	43	2,553	1,523	128	21,100	17,733	2,230	106

These figures of Ancylostome, Ascaris, and Trichuris infections in relation to mentality require careful consideration ; in the first place it is clear that the percentages of Ancylostome and Trichuris infections are about equal in all three groups ; the percentage of positive Ascaris cases is higher in Groups B and C, than in Group A, but the difference is not marked and the number of positive Ascaris cases dealt with is small. If we now consider the average degree of infection in the different groups, it is seen that in the case of Ascaris infection it is equal in all three groups, but that the Ancylostome and Trichuris infections are noticeably more intense in Groups B and C, than in Group A. In the Ancylostome infections Group B shows nearly four times, and Group C twice, as heavy an average degree of infection as Group A ; this can hardly be explained on the assumption that Ancylostome infection has exerted a deleterious effect on the mentality, for if this were so we would expect to find that Group C was more intensely infected than Group B, whereas the reverse is the case ; a similar state of affairs is also shown by the figures dealing with Trichuris infection. Table VIA, therefore, tends to disprove the theory that any relationship exists between the mentality of a group and the percentage of Ancylostome, Ascaris or Trichuris infected cases, or the degree of infection, occurring in that group.

It will be seen from Table VI that the proportionate sizes of the three groups in the mental classification bear no resemblance to those of the physical classification shown in Table IV ; in the mental classification the 137 natives examined are distributed amongst the three groups in the following proportions : Group A, twenty-five (18 per cent.), Group B, fifty-three (thirty-nine per cent.), Group C, fifty-nine (43 per cent.). Whereas all cases were examined for Ancylostomes, only eighty-nine cases were examined for Ascaris and Trichuris infections ; of these seventeen (19 per cent.) occurred in Group A, forty-three (48 per cent.) in Group B, and twenty-nine (33 per cent.) in Group C. Group A, therefore, forms much the smallest group in the mental classifications, whereas it formed much the largest group in the physical classifications. It is necessary to bear this fact in mind when considering the group distribution of the ten heaviest infections shown in Table VII.

Table VII.

Showing the ten heaviest Ancylostome, Ascaris, and Trichuris infections observed amongst West African natives, and the standard of mentality for each case.

Ancylostome				Ascaris			Trichuris		
Case	Standard of mentality	Number of ova per gm. of faeces	Computed number of Ancylostomes	Case	Standard of mentality	Number of ova per gm. of faeces	Case	Standard of mentality	Number of ova per gm. of faeces
113	C	124,000	5,167	38	B	42,630	43	C	7,800
43	C	36,830	1,537	74	B	19,500	20	C	2,230
44	B	23,100	962	66	C	17,733	15	B	1,000
71	C	21,100	879	30	A	17,400	73	B	933
114	C	17,760	740	43	B	16,630	74	B	900
33	B	15,600	650	115	A	10,300	60	B	460
35	B	13,700	570	117	B	9,430	119	B	400
60	B	13,600	567	57	C	9,130	14	B	360
76	B	13,400	558	72	B	8,700	49	B	330
38	B	13,200	550	65	C	4,260	22	A	300

Table VII shows that the distribution of the ten heaviest Ancylostome infections is, Group B, 60 per cent., Group C, 40 per cent. ; of the twenty-three natives not infected with Ancylostomes, 26 per cent. fell into Group A, 35 per cent. into Group B, and 39 per cent. into Group C. The distribution of the ten heaviest Ascaris infections was 20 per cent. in Group A, 50 per cent. in Group B, and 30 per cent. in Group C ; seventy-three cases negative for Ascaris occurred in the three groups in the following proportions :—Group A, 21.5 per cent., Group B, 48.5 per cent., Group C, 30 per cent. Amongst the ten heaviest Trichuris infections, 10 per cent. occurred in Group A, 70 per cent. in Group B, and 20 per cent. in Group C ; of the fifty natives not infected with Trichuris, 18 per cent. fell into Group A, 50 per cent. into Group B, and 32 per cent. into Group C. Analysis of these figures shows that the ten heaviest infections are distributed according to the size of the groups ; they also show that the proportion of cases amongst the ten heaviest infections occurring in the C, or mentally bad group, corresponds very closely with the proportion of cases occurring amongst uninfected natives in the same group. Intense infection, therefore, with Ancylostome, Ascaris, or Trichuris, does not necessarily result in a lowered standard of mentality.

Conclusions regarding the influence of Ancylostome infection on the mentality of 137 *West African natives and that of Ascaris and Trichuris infections on eighty-nine of the same cases.*

The conclusions reached are the same as those for physique and general fitness.

Reference has already been made to Strong's (1916) interesting monograph on the effects of hookworm disease on the mental and physical development of school children. It is not clear where the experiments described were carried out, but presumably they were in one of the American States, and possibly dealt with a less resistant race than the West African native.

Butler (1915), working at the Bo School for the sons of Chiefs in Sierra Leone, wrote as follows : ' *Examination for Ankylostomiasis.*—The same seventy-five boys were examined also for this condition, and in only one case was there a negative result ; that is, 98.6 per cent. showed the presence of ancylostome ova. I think these cases may be regarded as fairly heavy infections, because in fifty-nine of the cases (that is, roughly, 80 per cent.) the ova were found in a single examination of crude faeces. None of the individuals showed any symptoms or signs suggestive of ankylostomiasis. Duffers and individuals of acute intelligence appeared equally infected, and the standard of the school sports is quite as high as the average English Public School, so that I could not detect any evidence suggesting that these individuals suffered any disability from harbouring the parasite at that particular time, though symptoms of ankylostomiasis might quite likely appear if the individual was placed under some untoward condition, such as semi-starvation, when the ancylostome toxins might get the upper hand.' Easmon (1923), writing of the same school, repeats Butler's observations. These two papers are not based on any exact data, and are not quoted here as supporting the theory regarding the non-pathogenicity of ankylostomiasis; they are referred to merely because the present writer believes that they represent the views of the majority of medical men in Sierra Leone.

(D) *Energy*. The definition of energy has already been given as the keenness with which an individual attempts any mental or physical task allotted to him. The data collected regarding the percentage and degree of infection amongst West African natives, classified in three groups on this basis, are set forth in Table VIII.

TABLE VIII.

Showing the percentage of individuals infected with Ancylostome, Ascaris, and Trichuris, and the average degree of infection, amongst West African natives arranged in three groups according to their energy.

Groups based on energy	Number of cases examined	Percentage infected with			Average number of ova per gm. of faeces			Maximum number of ova per gm. of faeces			Computed average number of Ancylostomes per individual
		Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	
A (Good)	For Ancylostomes only—20 For Ancylostomes, Ascaris and Trichuris—27	72	19	37	1,990	1,677	94	12,660	17,400	933	83
(B) (Moderate)	For Ancylostomes only—0 For Ancylostomes, Ascaris and Trichuris—33	85	18	45	4,064	2,586	99	15,600	42,630	900	169
C (Bad)	For Ancylostomes only—28 For Ancylostomes, Ascaris and Trichuris—29	91	17	45	5,681	1,429	423	124,000	17,733	7,800	237

In Table VIII the predominant Trichuris, and the two predominant Ancylostome infections, both occur in Group C ; while the predominant Ascaris infection occurs in Group B. If, as before, we omit these four infections, the results are as shown in Table VIIIA.

TABLE VIIIA.

Same as Table VIII except that four predominantly high infections have been omitted.

Groups based on energy	Numbers of cases examined	Percentage infected with			Average number of ova per gm. of faeces			Maximum number of ova per gm. of faeces			Computed average number of Ancylostomes per individual
		Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	Ancylostome	Ascaris	Trichuris	
A (Good)	For Ancylostomes only—20 For Ancylostomes, Ascaris and Trichuris—27	72	19	37	1,990	1,677	94	12,660	17,400	933	83
B (Moderate)	For Ancylostomes only—0 For Ancylostomes, Ascaris and Trichuris—32	85	16	45	4,064	1,334	99	15,600	19,500	900	169
C (Bad)	For Ancylostomes only—27 For Ancylostomes, Ascaris and Trichuris—28	91	17	43	2,963	1,429	160	23,100	17,733	2,230	123

Consideration of Table VIIIA shows that Ascaris and Trichuris infections are in no way associated with a lowered standard of energy. As regards Ancylostome infection, it is seen that the percentage of infected cases in each group increases with each reduction in the standard of energy ; but this increase in the percentage of infected cases is only as 72-85-91 and is, therefore, obviously too small to allow of any conclusions. The average degree of infection is higher in both Group B and Group C than it is in Group A, but, as was also found in the mental classification, the degree of infection in Group B is higher than in Group C, which represents a lower standard of energy, the ratio of A-B-C being as 2-4-3. Before studying the results of intense infection on the energy of the individual, as shown in Table IX, it is necessary to consider the proportionate sizes of the different energy groups shown in Table VIII ; from this table it can be seen that, of 137 natives examined for ancylostomes, forty-seven (34 per cent.) occurred in Group A, thirty-three (24 per cent.) occurred in Group B, and fifty-seven (42 per cent.) in Group C. Eighty-nine natives were examined for Ascaris and Trichuris infection ; of these twenty-seven (30 per cent.) fell into Group A, thirty-three (37 per cent.) into Group B, and twenty-nine (33 per cent.) into Group C.

TABLE IX.

Showing the ten heaviest Ancylostome, Ascaris, and Trichuris infections observed amongst West African natives, and the standard of energy for each case.

Ancylostome				Ascaris			Trichuris		
Case	Standard of energy	Number of ova per gm. of faeces	Computed number of Ancylostomes	Case	Standard of energy	Number of ova per gm. of faeces	Case	Standard of energy	Number of ova per gm. of faeces
113	C	124,000	5,167	38	B	42,630	43	C	7,800
43	C	36,830	1,537	74	B	19,500	20	C	2,230
44	C	23,100	962	66	C	17,730	15	C	1,000
71	C	21,100	879	30	A	17,400	73	A	933
114	C	17,760	740	43	C	16,630	74	B	900
33	B	15,600	650	115	A	10,300	60	B	460
35	B	13,700	570	117	A	9,430	119	B	400
60	B	13,600	567	57	B	9,130	14	A	360
78	B	13,400	558	72	B	8,700	49	C	330
38	B	13,200	550	65	A	4,260	22	A	300

The figures in Table IX show that amongst the ten most intensely infected ancylostome cases, 50 per cent. fall into Group B and 50 per cent. into Group C ; twenty-three natives were negative for ancylostomes and these were distributed in the proportions of 56 per cent. in Group A, and 22 per cent. in both Group B and Group C. The distribution of the ten heaviest Ascaris infections was, 40 per cent. in Group A, 40 per cent. in Group B, and 20 per cent. in Group C ; seventy-three cases were negative for Ascaris and were distributed as follows : Group A, 30 per cent., Group B, 37 per cent., Group C, 33 per cent. Amongst the ten heaviest Trichuris infections 30 per cent. occurred in Group A, 30 per cent. in Group B, and 40 per cent. in Group C ; fifty cases were negative for Trichuris ; of these 34 per cent. occurred in Group A, 34 per cent. in Group B, and 32 per cent. in Group C.

An examination of the figures in Table VIII has already shown that the numbers of natives examined for Ascaris and Trichuris infections were about equally distributed in the three groups. It will be seen from the figures above recorded that the intensely infected Ascaris and Trichuris cases, and also the cases free from these infections, likewise distribute themselves in more or less equal groups ; that is to say, they occur in the proportions that would be expected if these two infections had no influence on energy.

The Ancylostome figures are of interest as they appear to indicate some connection between intense infection with ancylostomes and a lowered standard of energy ; thus none of the ten heaviest infections occur in Energy Group A, whereas of the twenty-three uninfected cases, 56 per cent. fall into this category ; Group C contains not only 50 per cent. of the ten heaviest infections, but the five most intense of these ten infections all fall into this class, whereas it contains only 22 per cent. of the uninfected cases. The figures seem to suggest, therefore, that very intense Ancylostome infections, represented by more than 15,000 ova per gm. of faeces, may possibly have a deleterious effect on the energy of the individual so infected.

Conclusions regarding the influence of Ancylostome infection on the energy of 137 *West African natives, and that of Ascaris and Trichuris on eighty-nine of the same cases.*

1. A group of individuals with a lower standard of energy does not necessarily show a noticeably greater percentage of infected cases than a group with a higher standard of energy.

2. A group with a lower standard of energy does not necessarily show a noticeably greater average degree of infection than a group with a higher standard of energy.

3. (*a*) Individuals with a high degree of infection with Ascaris or Trichuris do not necessarily show a low standard of energy.

(*b*) The figures, such as they are, suggest that there may be some correlation between Ancylostome infections of more than 15,000 ova per gm. of faeces, and the low standard of energy observed in such cases ; but it is obvious that to justify any definite conclusion of this kind the work must be repeated with very much larger groups of cases.

(E) *Urine.* Eighty-two natives—in whom the degree of infection with Ancylostome, Ascaris, and Trichuris, was already known—were examined for the presence of albumin and (or) casts in the urine; twenty-seven (33 per cent.) of the cases were positive for albumin; none of the cases showed the presence of casts. No association between the presence of Ancylostome, Ascaris, or Trichuris ova in the faeces and albumin in the urine could be demonstrated; nor was a high degree of infection with any of these worms necessarily associated with the presence of albumin in the urine. The high percentage of albuminurias is probably due to the frequent occurrence of chronic gonorrhoea amongst certain classes of the native population.

VI. EFFECT OF MIXED INFECTIONS

Mixed infections were common amongst the natives examined and it is obviously impossible to set forth briefly the results of different worm combinations. Tables showing the effects of mixed infections with any two species of worms under consideration have been prepared by the writer, with the result that no association has been demonstrated between any such double infection and a lowered standard of haemoglobin percentage, physique, mentality, or energy. Only five of the eighty-nine natives examined for Ancylostome, Ascaris, and Trichuris revealed the presence of all three infections in the one individual, and the full data regarding these five cases is set forth in Table X.

Table X.

Showing the degree of infection and the corresponding classification according to haemoglobin percentage, physique, mentality, and energy, of five cases of mixed infection with Ancylostome, Ascaris, and Trichuris, occurring amongst West African natives; also the presence or absence of albumin in the urine of such cases.

Case	Number of Ancylostome ova per gm. of faeces	Number of Ascaris ova per gm. of faeces	Number of Trichuris ova per gm. of faeces	Haemoglobin group	Physique group	Mentality group	Energy group	Albuminuria
38	13,200	42,630	33	A (80%)	A	B	B	Negative.
43	36,830	16,330	7,800	—	B	C	C	Positive.
64	363	366	163	A (85%)	A	C	C	Negative.
74	333	19,500	900	B (75%)	A	B	B	Negative.
75	3,300	2,630	100	A (80%)	A	C	B	Positive.

Table X shows that mixed infections with Ancylostome, Ascaris, and Trichuris, are not necessarily associated with albuminuria or a lowered standard of haemoglobin percentage, physique, mentality, or energy.

VII. SUMMARY OF CONCLUSIONS

A study of the effects of ankylostomiasis on the health of 137 West African natives, and those of Ascaris and Trichuris on eighty-nine of the same cases, has shown that these infections, or a combination of these infections, produce no noticeable effects on the haemoglobin percentage, the physique and general fitness, or the mentality of the cases examined, nor is their presence in any way associated with albumin or casts in the urine. Ascaris, and Trichuris infections do not appear to be associated with a low standard of energy, nor are the percentage of Ancylostome infected cases, or the average degree of infection, necessarily noticeably greater in a group of individuals with a lower standard of energy than in one with a higher standard. On the other hand, the figures suggest the possibility of some association between Ancylostome infections of more than 15,000 ova per gm. of faeces, and the low standard of energy observed in such cases ; but only a few such intense infections were observed, and it is obvious that in order to justify any such definite conclusion the work must be repeated with very much larger groups of cases.

It therefore follows from these conclusions that before treatment, and especially before the so-called 'Mass treatment,' of ankylostomiasis, is applied to any native race, careful investigation should be made whether ankylostomiasis has any definite pathogenic effect on that race, and if pathogenic effects are noted, with what degree of infection they are associated.

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EXPLANATION OF PLATE VII

FIG. 1. Showing the physical condition of six boys selected at random from amongst the negative or lightly infected Ancylostome cases.

FIG. 2. Showing the physical condition of six boys selected at random from amongst the heaviest Ancylostome infections.

Number of Ova per gm. of faeces	*Ancylostome*	433	0	200	900	0	0
	Ascaris ...	8,200	9,400	17,730	0	2,733	0
	Trichuris ...	0	100	0	0	400	166

FIG. 1

Number of Ova per gm. of faeces	*Ancylostome*	36,830	23,100	21,000	15,600	13,200	13,700
	Ascaris ...	16,330	0	0	0	42,630	0
	Trichuris ...	7,800	0	0	0	33	66

FIG. 2

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